Edema and its Reduction: Is there a Therapeutic Electromagnetic Link?

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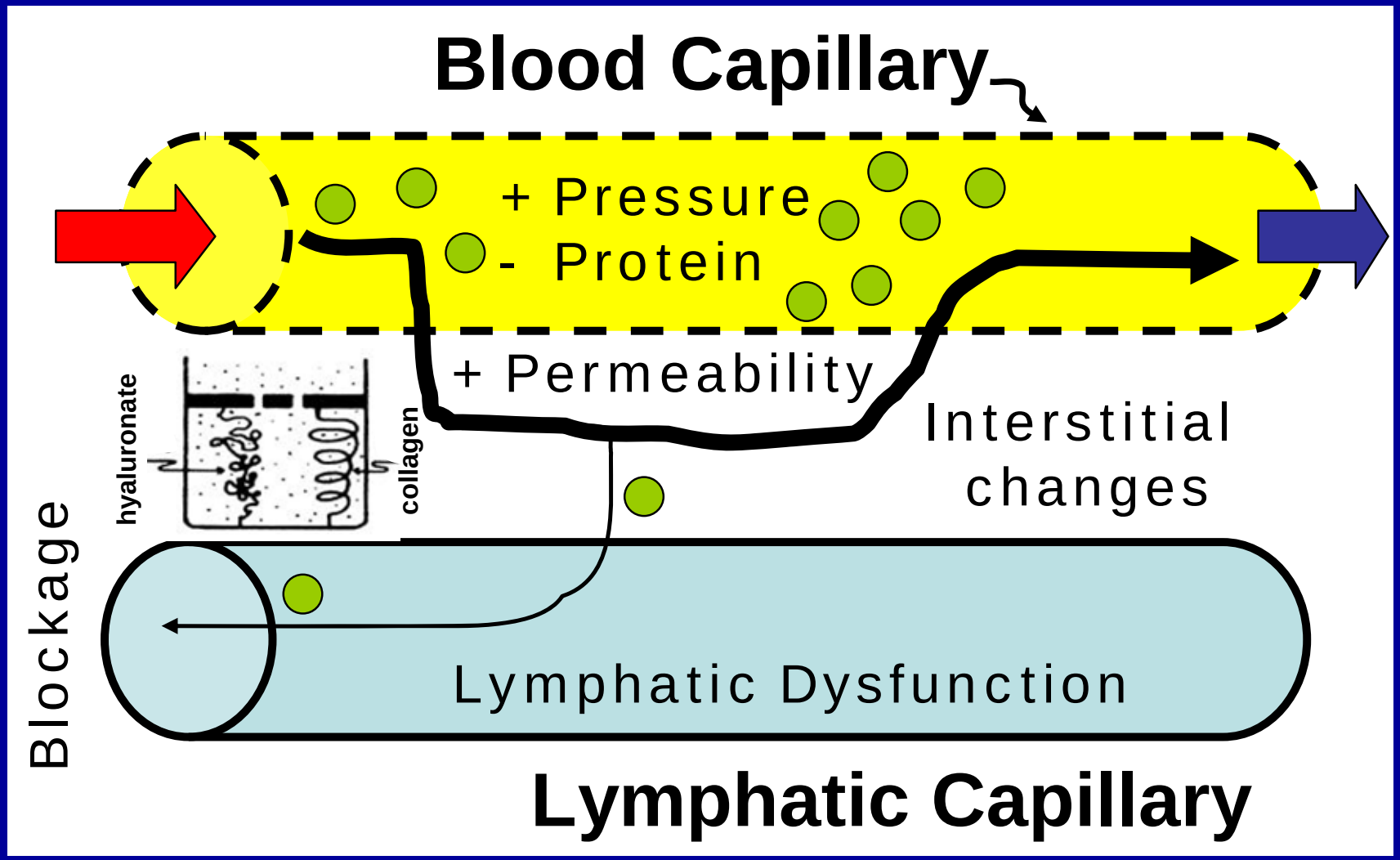
Professor of Physiology

What is Edema?

Swelling

What Causes Edema?

More Fluid is Filtered than can be Removed



How Might Electromagnetism Fit In?

Short answer
Almost all aspects of all bodily functions have an electrical component

Interacting Voltages and Ionic Currents

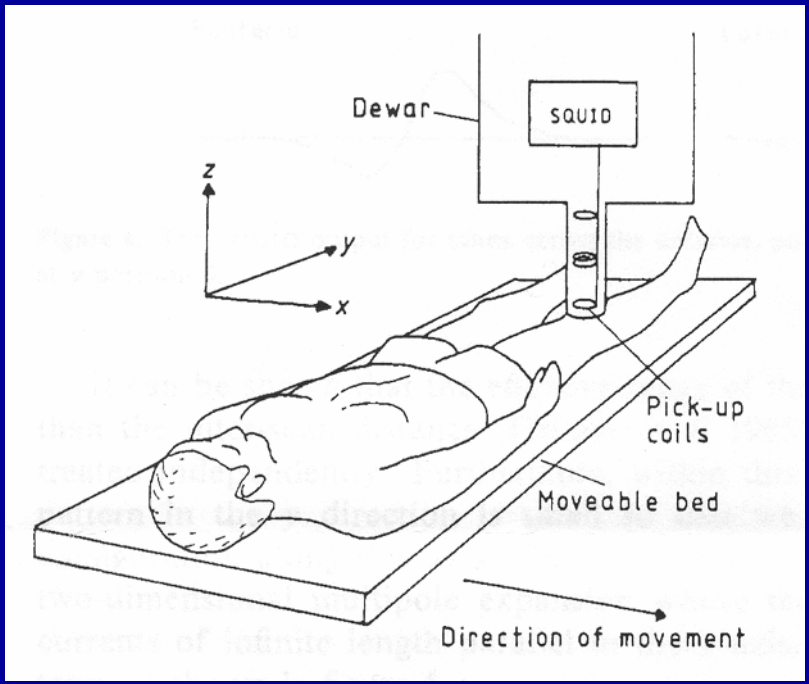
- Central & Peripheral Nervous Systems
- Cellular Membranes

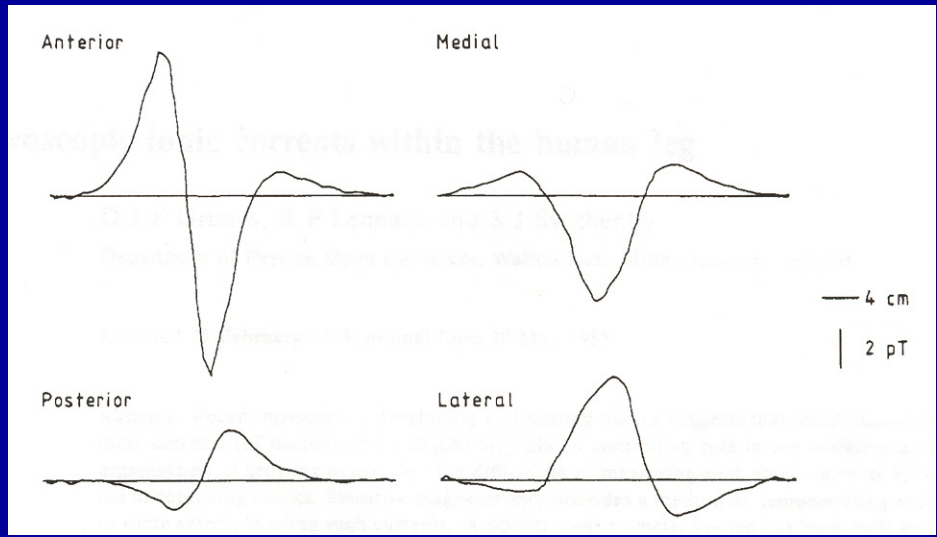
} 100 mv

- Surface Charges
- Streaming Potentials

Thus there are ample *potential* targets for applied EMF

Macroscopic ionic currents are present in normal tissue

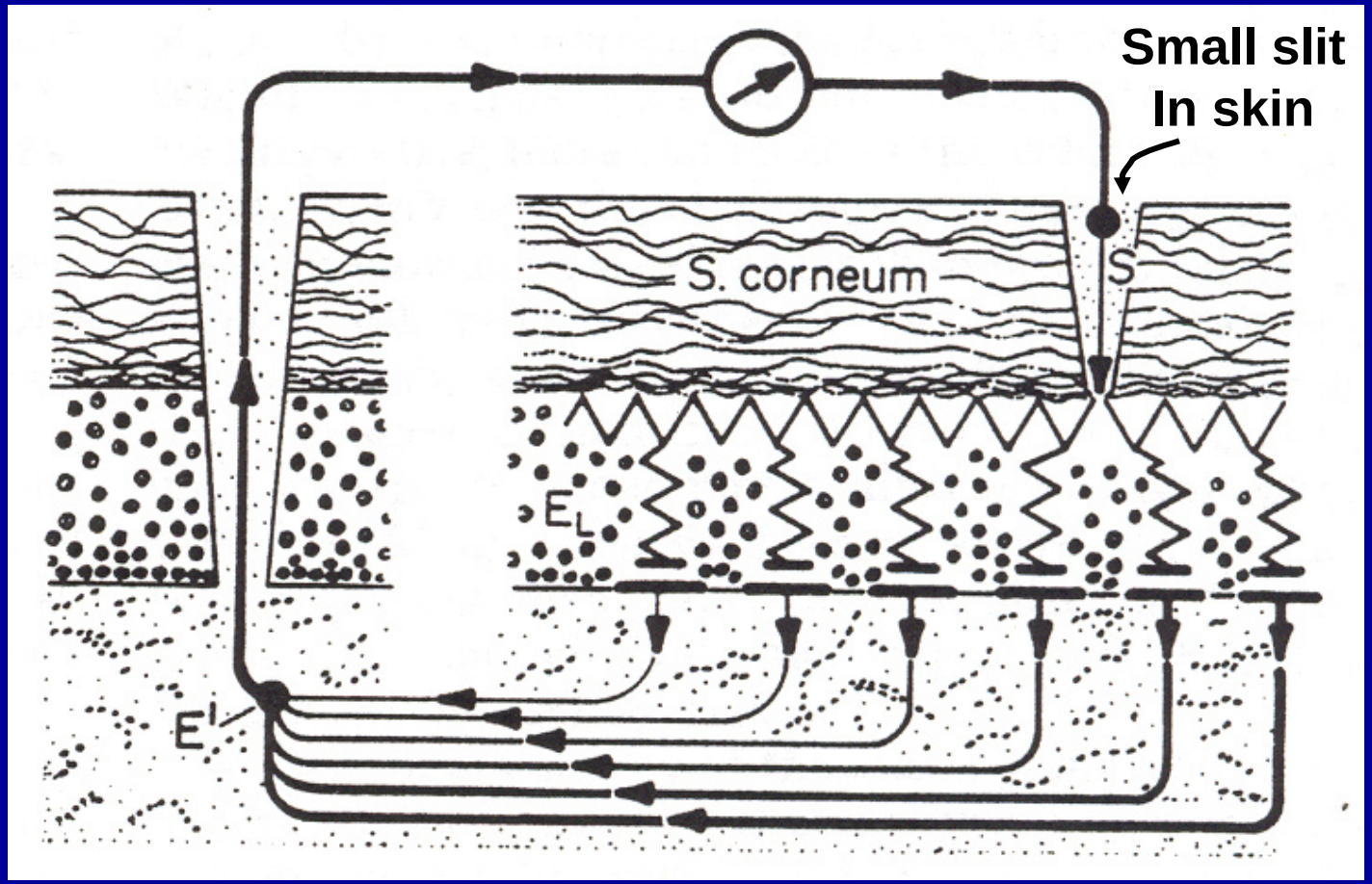




Grimes et al. Phys Med Biol 1985;30:1101-1112

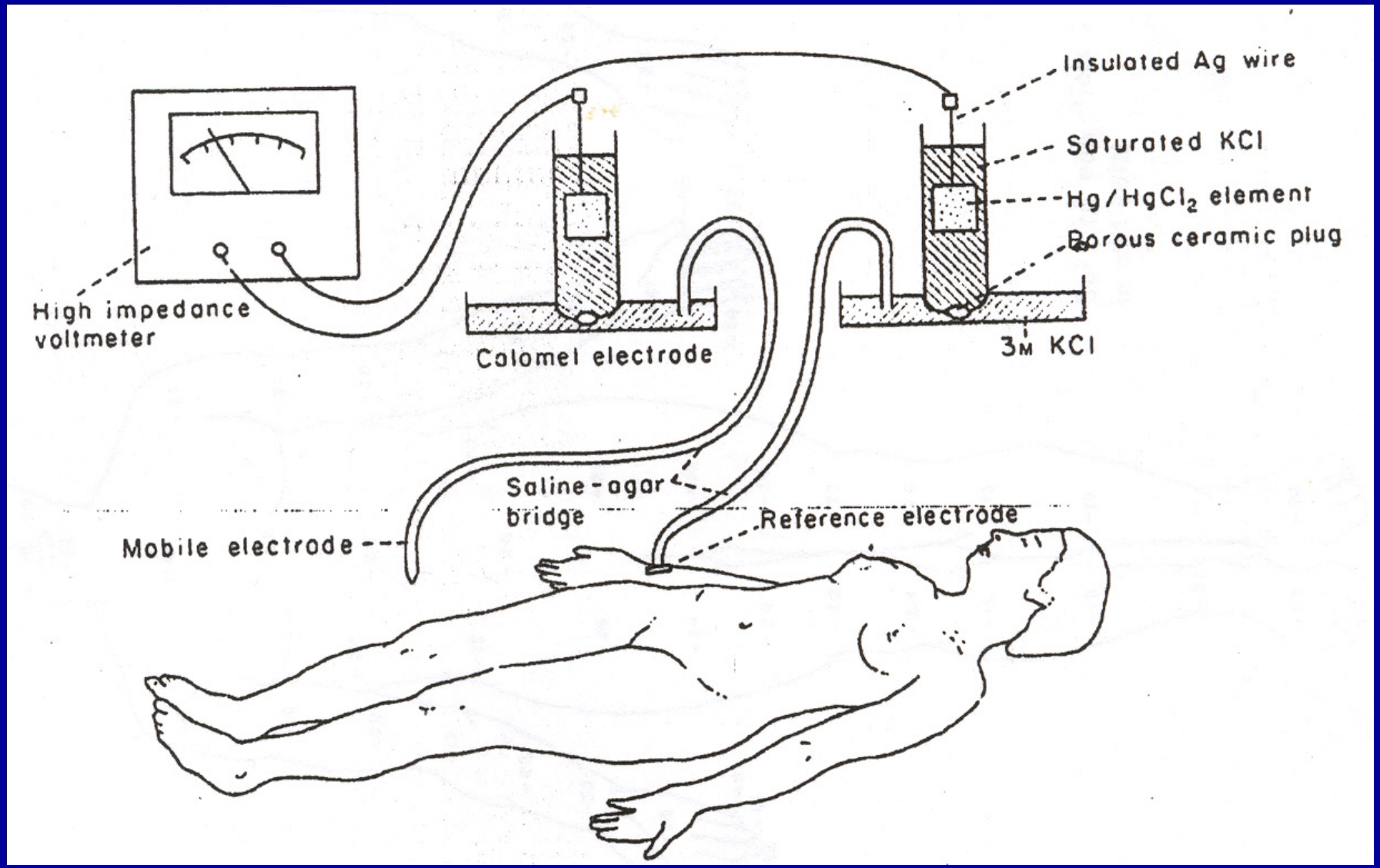
Human Skin is like a Battery

Directly Measured Currents



Barker et al. AJP 1982;242:R358-R366

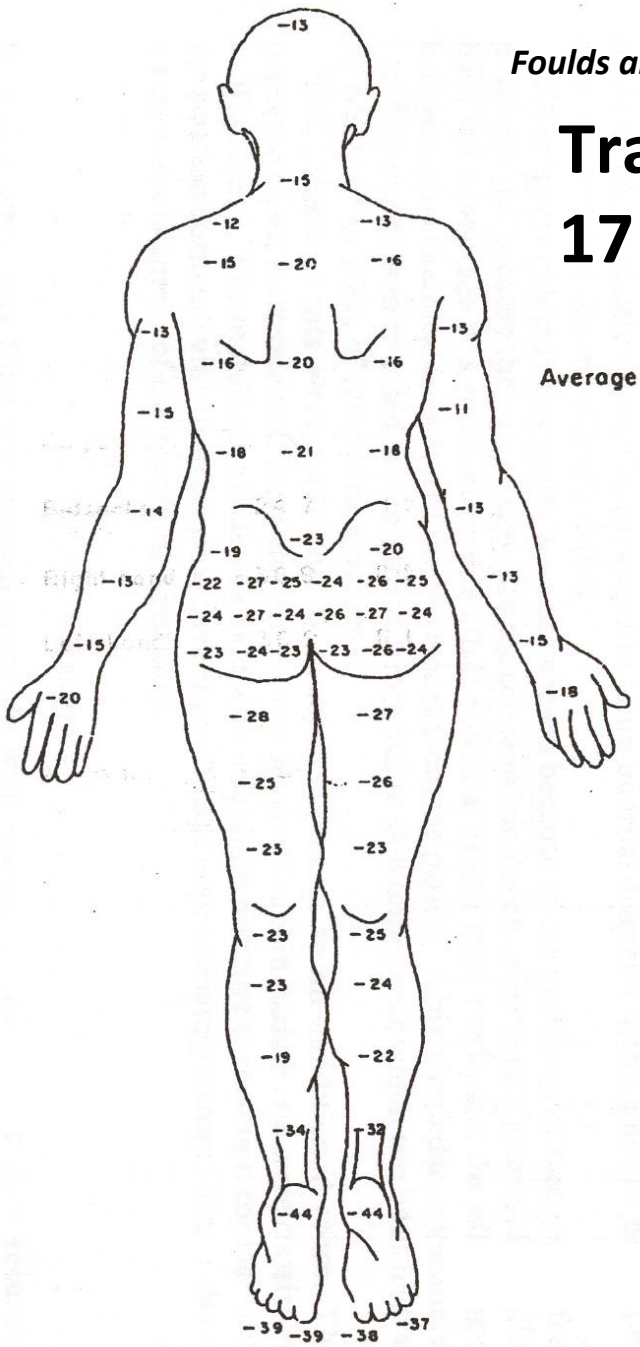
Human Skin Surface Voltages



Foulds and Barker Br J Dermatology 1983;109:515-522

Foulds and Barker Br J Dermatology 1983;109:515-522

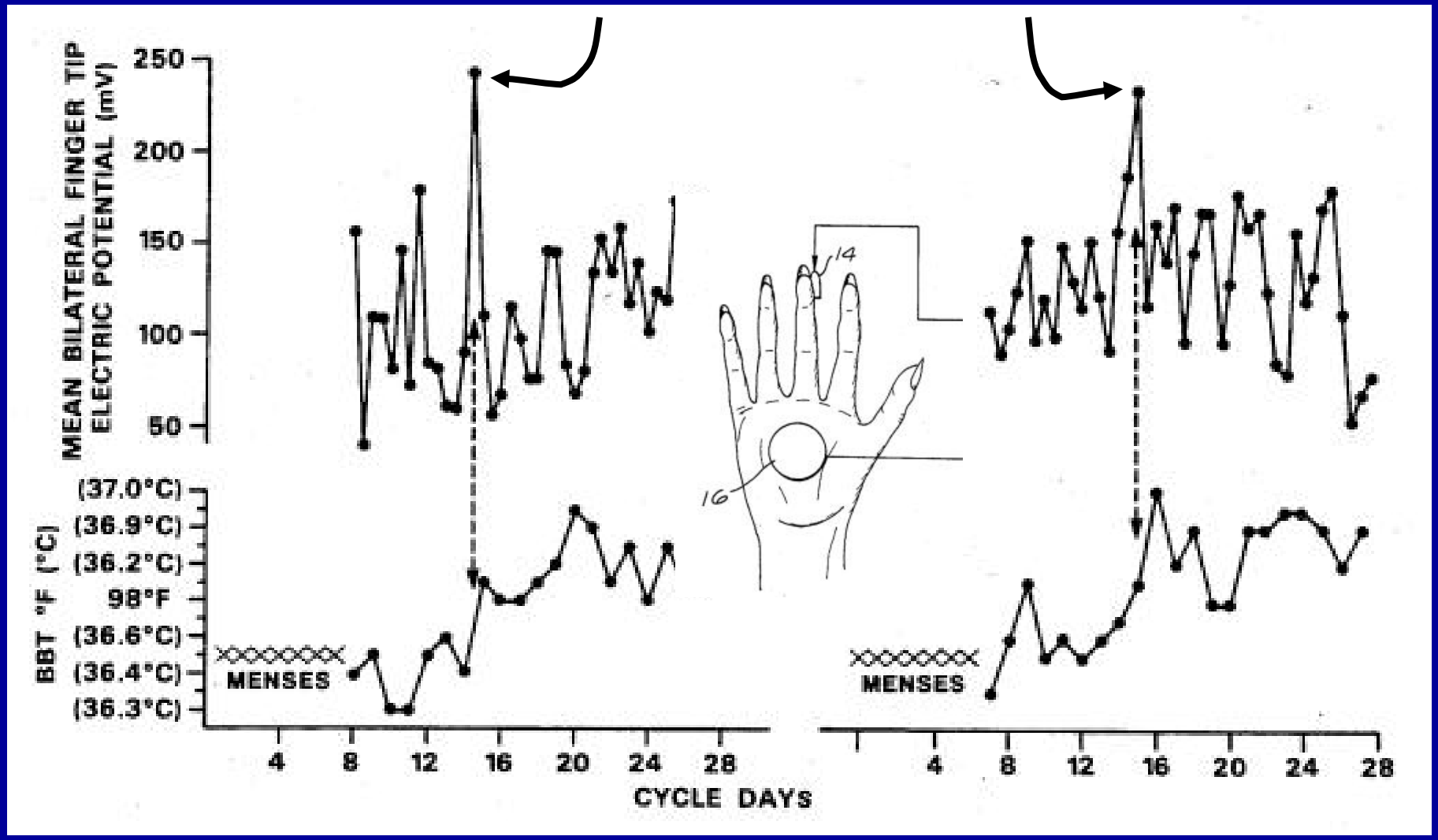
Trans-skin Voltages in 17 "normal" subjects



Average potential and standard deviation

All points	−23·4	8·6
Buttocks	−24·7	1·5
Right hand	−36·9	8·8
Left hand	−36·9	8·1
Feet	−39·0	3·4
Right leg	−23·4	4·5
Left leg	−24·1	4·0
Right arm	−14·7	3·2
Left arm	−16·2	3·5
Back	−17·5	3·1
Front	−18·8	3·5
Head	−16·3	5·4

Peaking of Skin Potential Around Ovulation



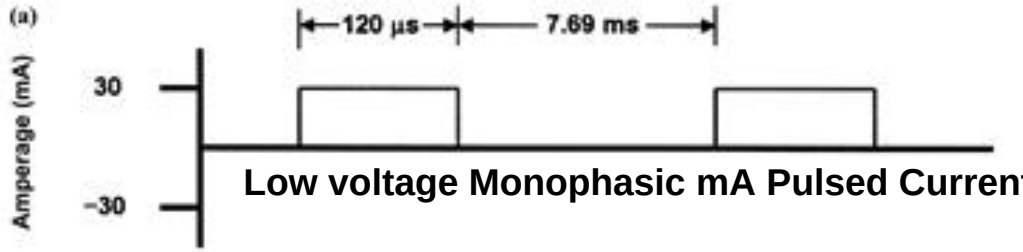
26 year old subject over one month

From patent # 4557273

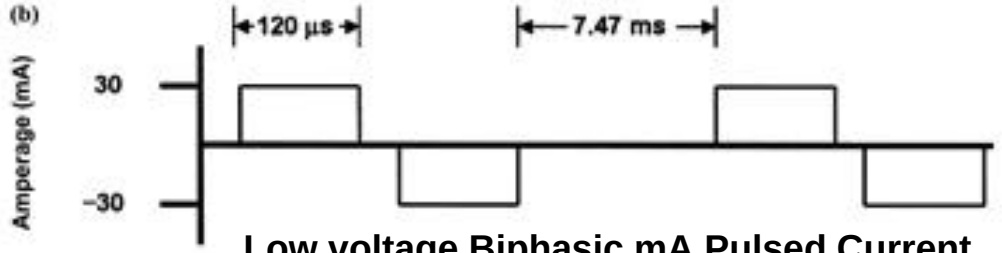
EMF Application Modalities

Electrodes (Contact) & Electrode-less (Non-Contact)

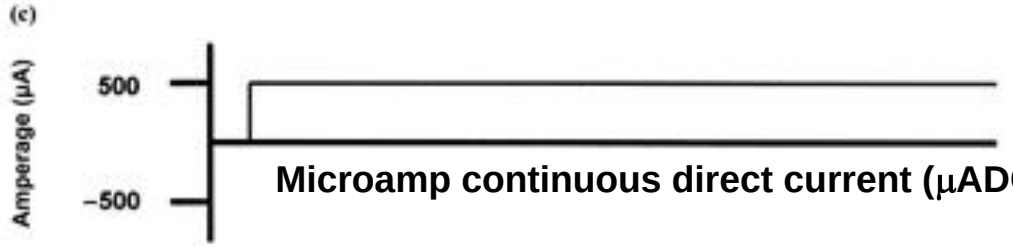
Contact Electro-Stimulation



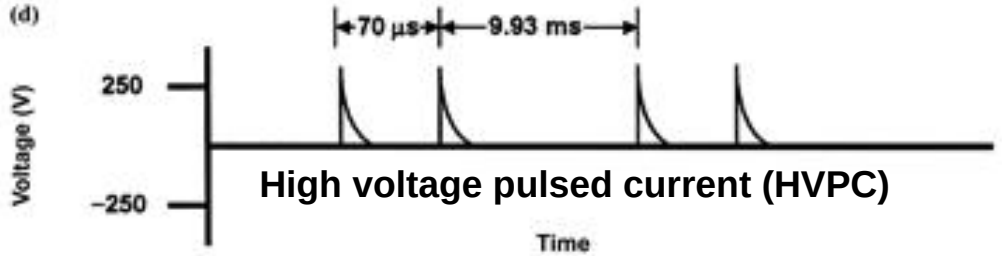
Low voltage Monophasic mA Pulsed Current



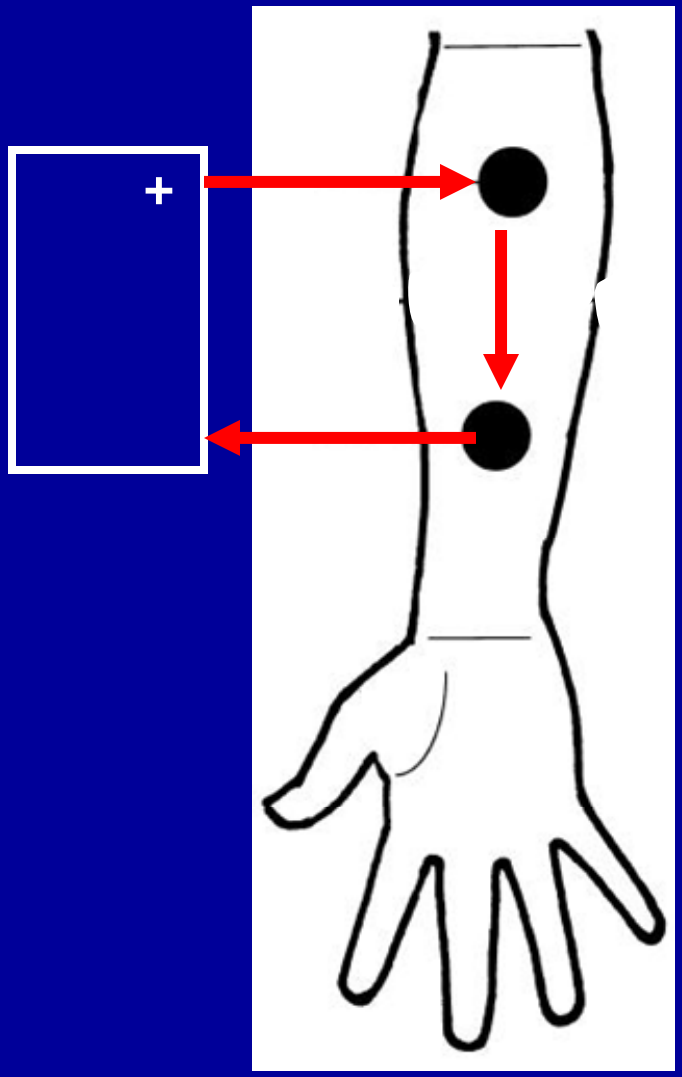
Low voltage Biphasic mA Pulsed Current



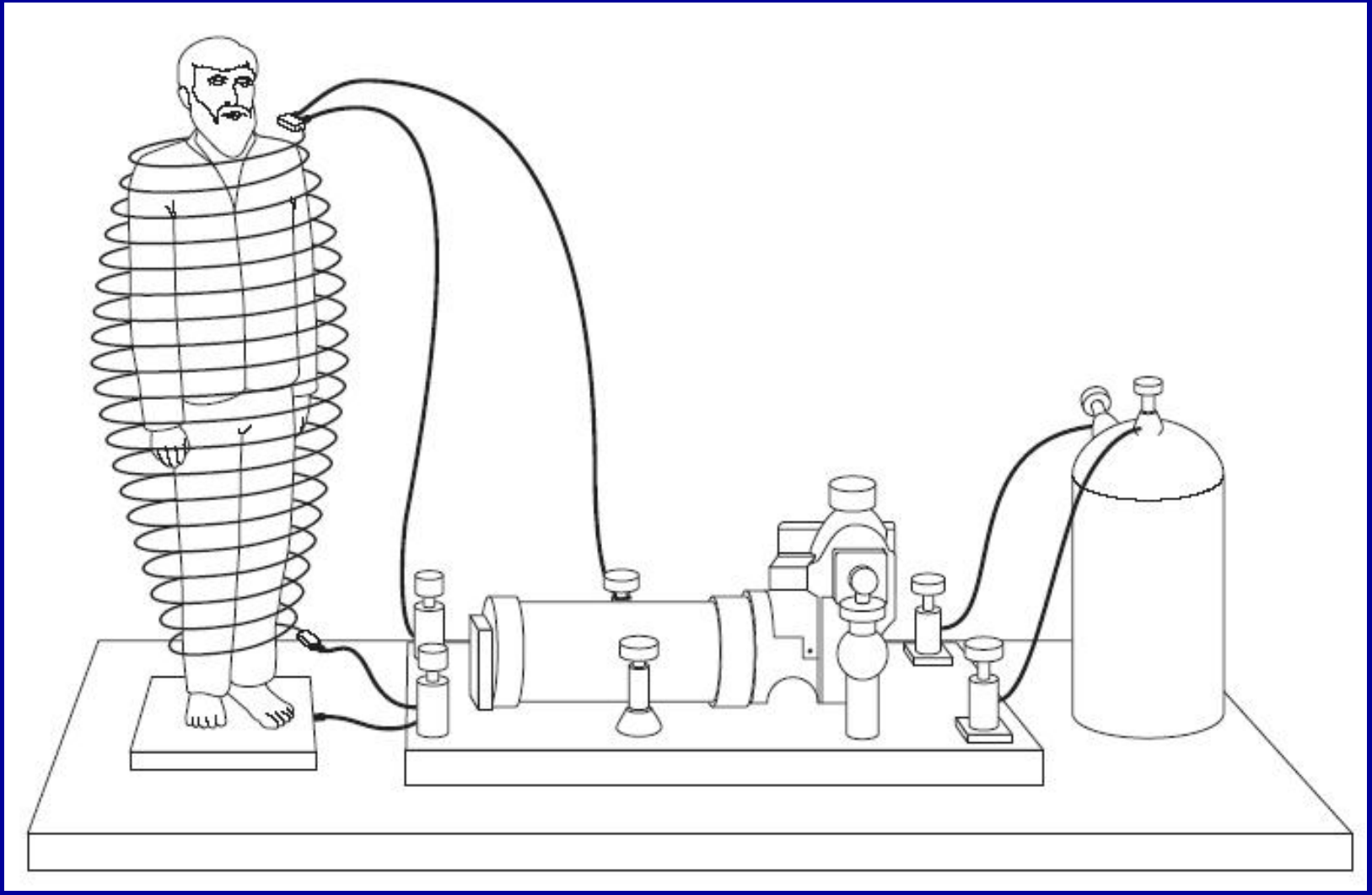
Microamp continuous direct current (µADC)



High voltage pulsed current (HVPC)

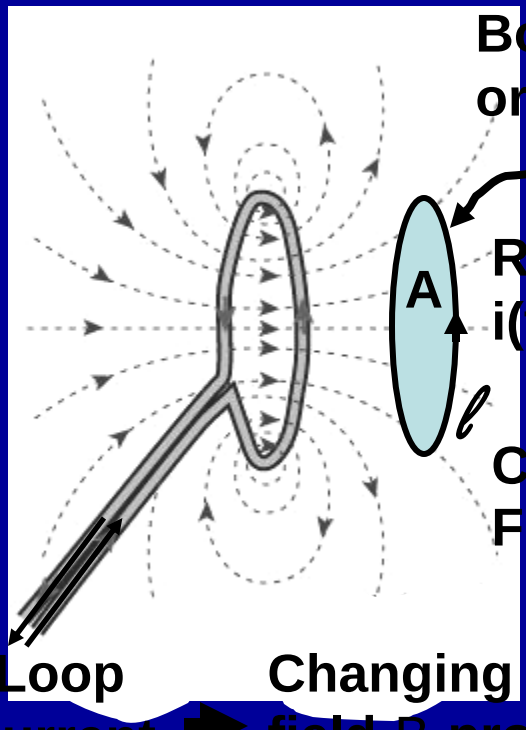


Non-Contact Electromagnetic *Induction*



Patent 96,044 1869

Electromagnetic Induction Basic Considerations



Resulting in an
i(t) = induced current

Causes an Electric
Field E to be induced

Changing Magnetic
field B produced by
changing loop current

Loop
Current
$i_L(t)$

$$J(t) = E(t) \times G_{TISSUE}$$

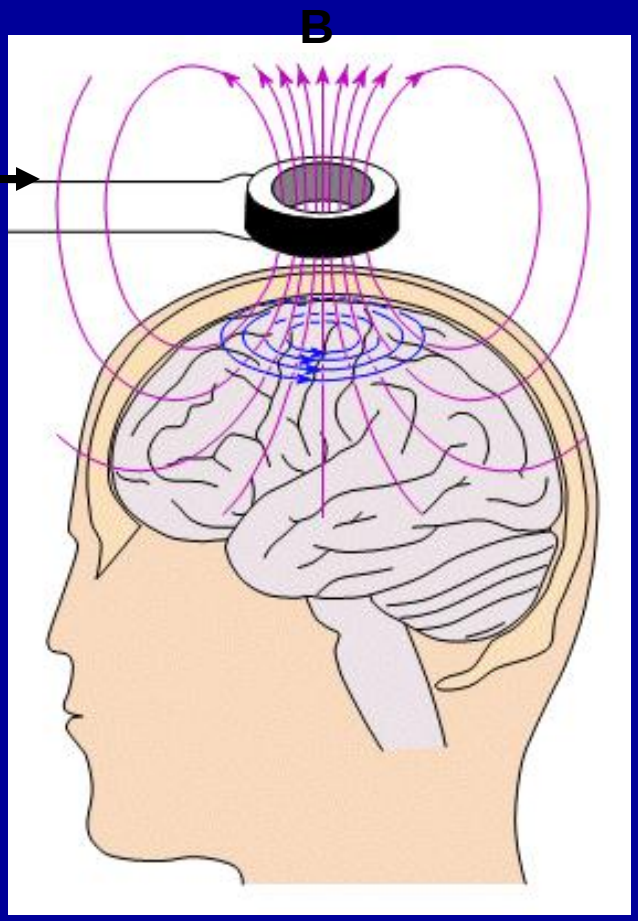
Amps/m^2 Siemens/m

$$E = V/\ell = (A/\ell)dB/dt$$

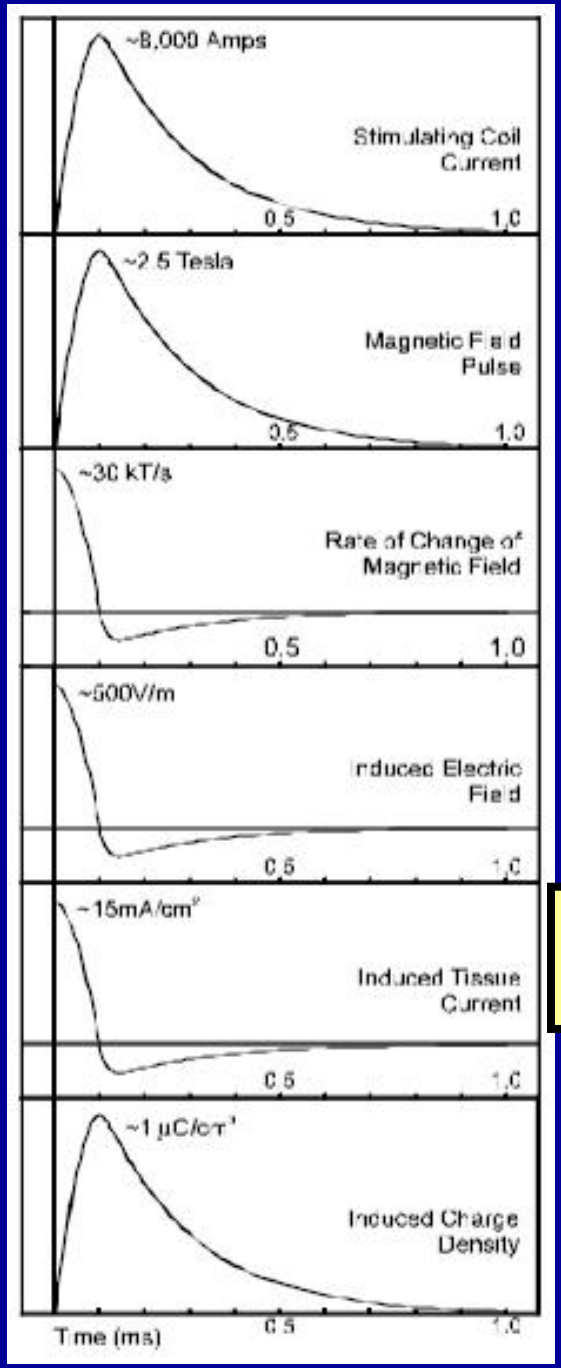
For a circular area

$$E = V/\ell = (R/2)dB/dt$$

R ~ meters
B ~ Tesla
t ~ seconds
E ~ volts/meter



Transcranial Magnetic Stimulation (TMS)

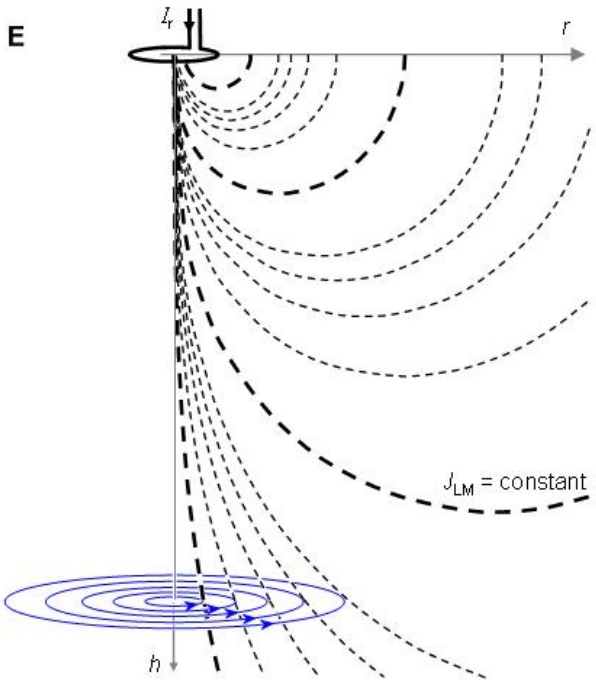


Body Tissue	Conductivity
Blood Plasma	1.4 S/m
Spinal Fluid	1.4
Nerve, axoplasm	0.91
Whole Blood	0.62
Skeletal Muscle, long axis	0.53
Brain, grey matter	0.45
Nerve, extracellular fluid	0.33
Brain, white matter	0.15
Liver	0.14
Bone, longitudinal direction	0.067

$$J(t) = E(t) \times G_{TISSUE}$$

Amps/m² Siemens/m

Field Patterns and Intensity



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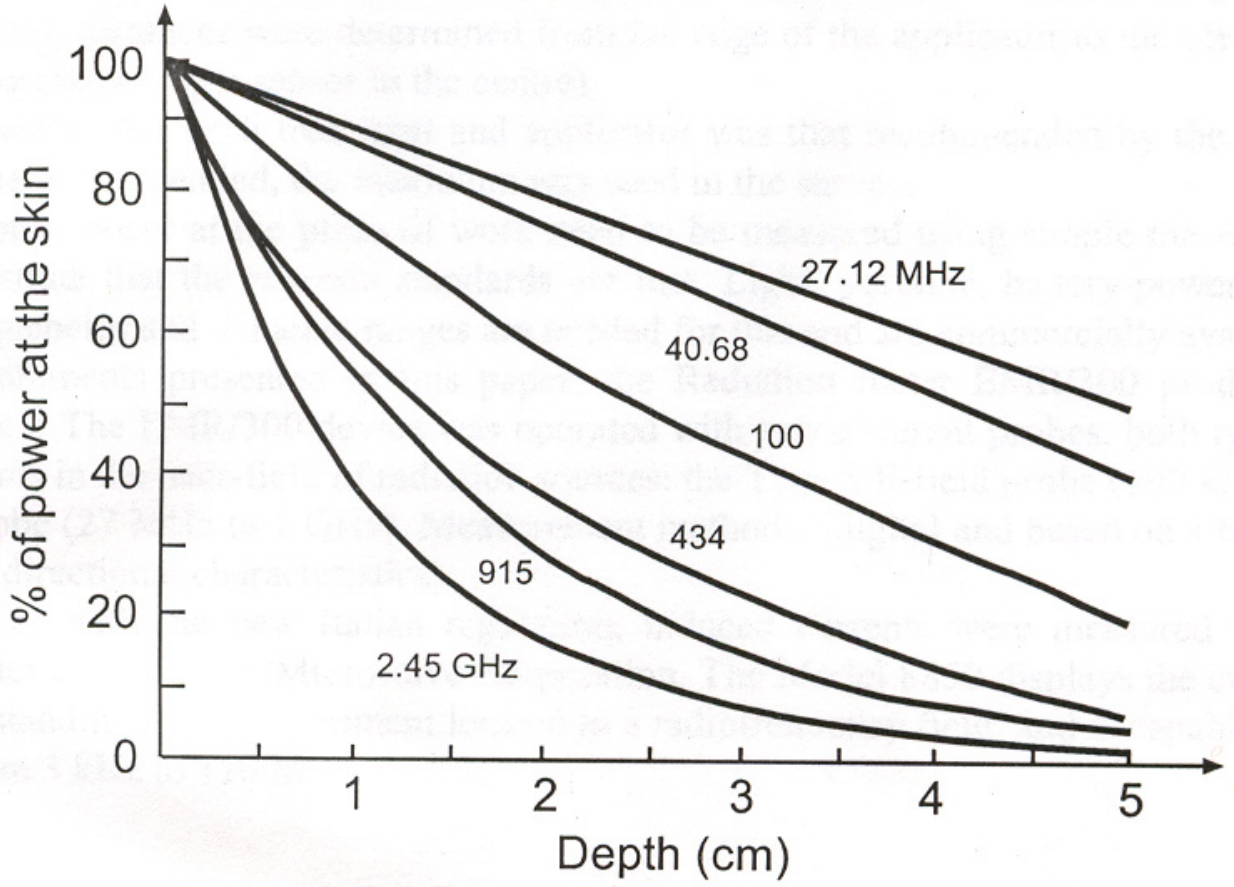
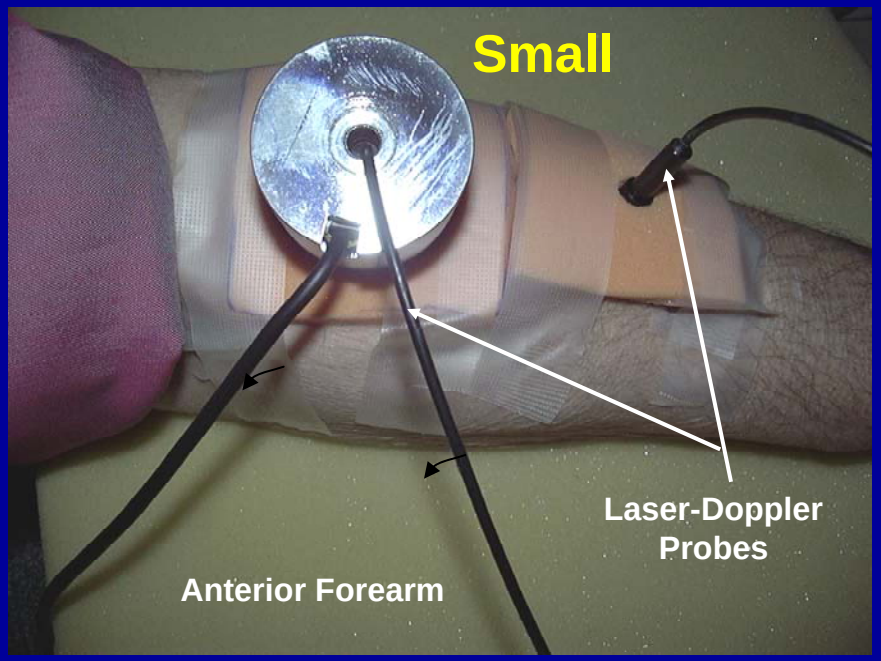
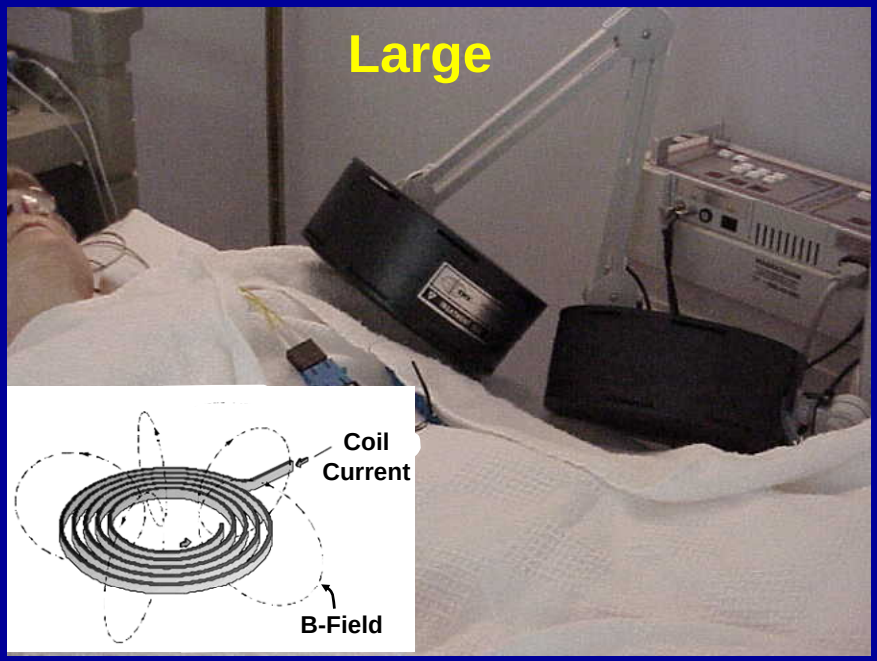
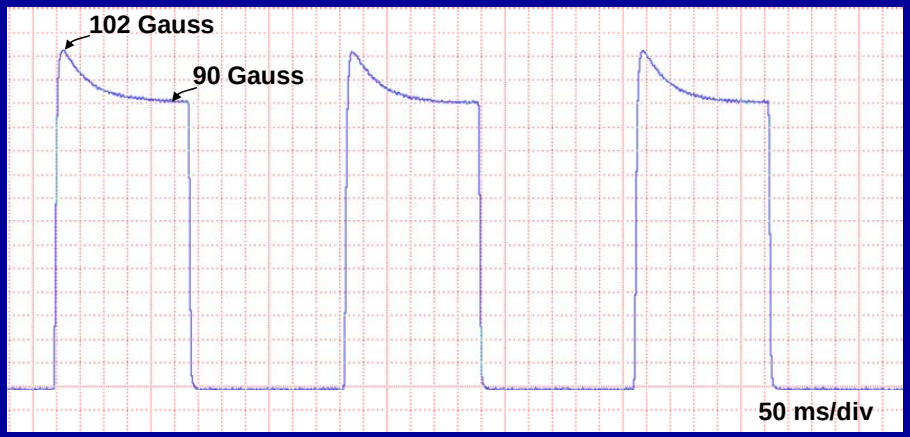


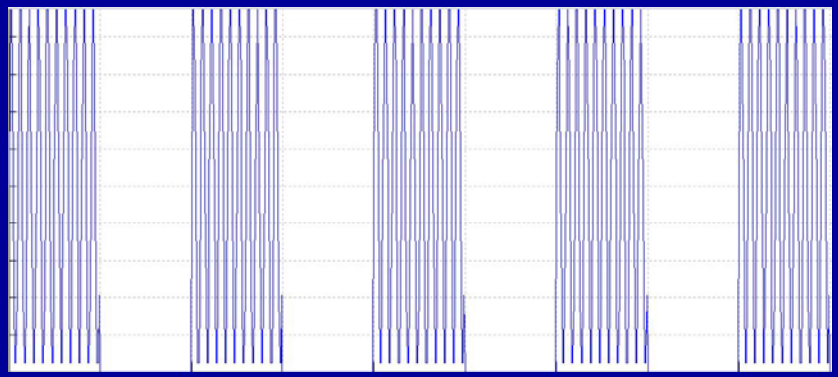
Electromagnetic Applications







1 Hz

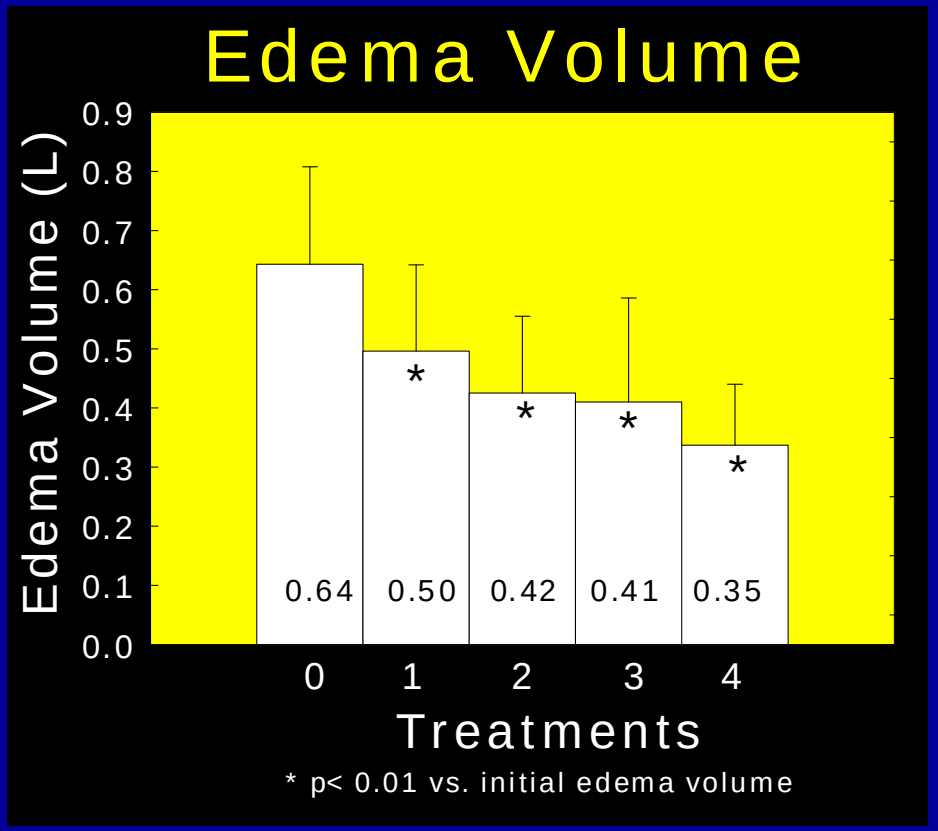


27.1 MHz

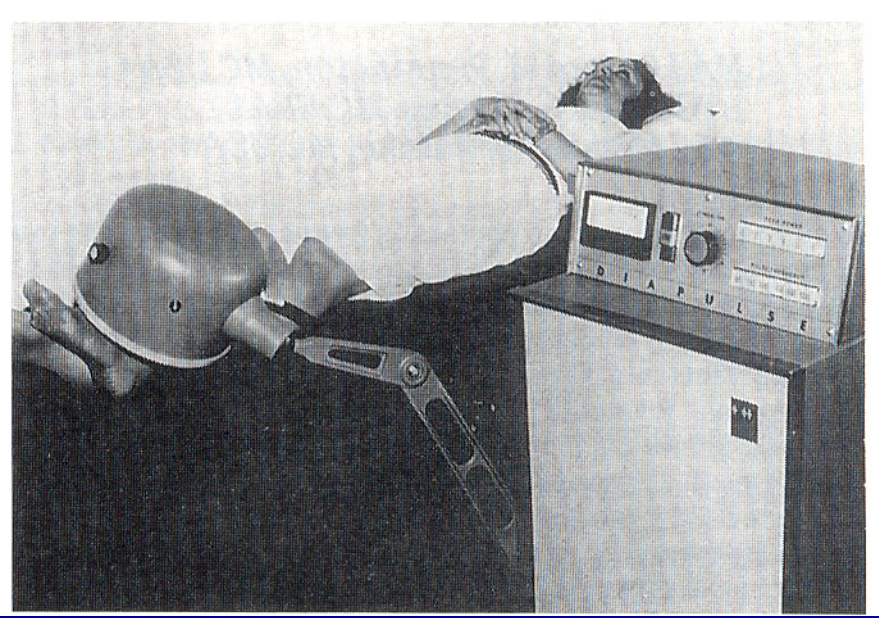
Evidence?

Lymphedema

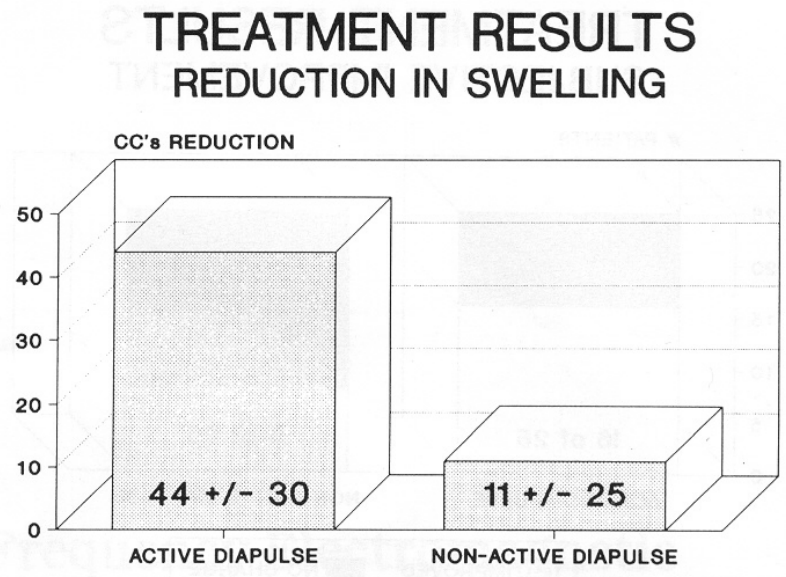
- High protein content edema secondary to node removal and/or radiation therapy
- Occurs in 20-40% of postmastectomy women from months to years after surgery
- Usually progressive if untreated - Fibrosis

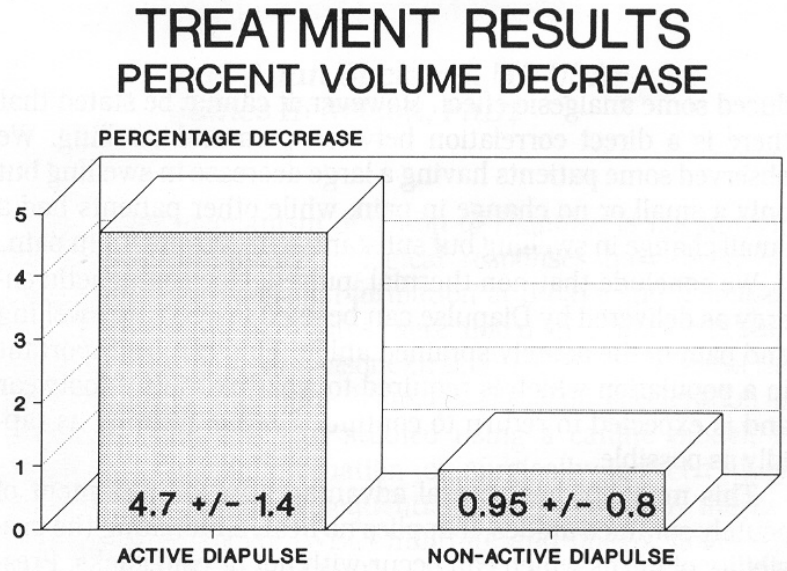


Edema



Treatment of 50 Ankle Sprains
Within 72 hours of injury
30 minutes – medial
30 minutes – lateral
10 minutes – epigastric
Volumes measured
Before and After





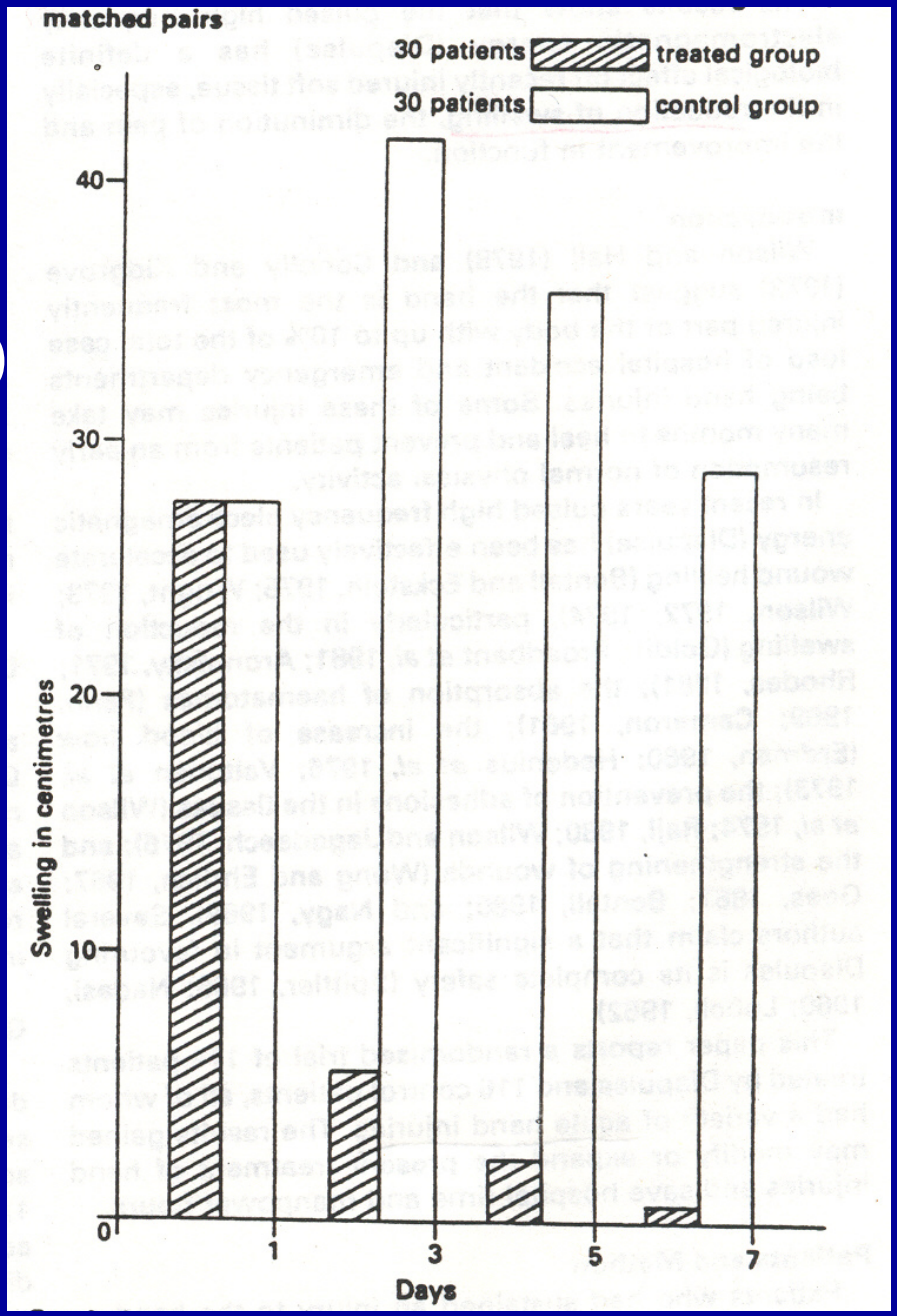
Pennington GM et al. Military Medicine 1993;158:101-104

Edema

230 Hand or Thumb Injuries
Seen within 36 hours of injury

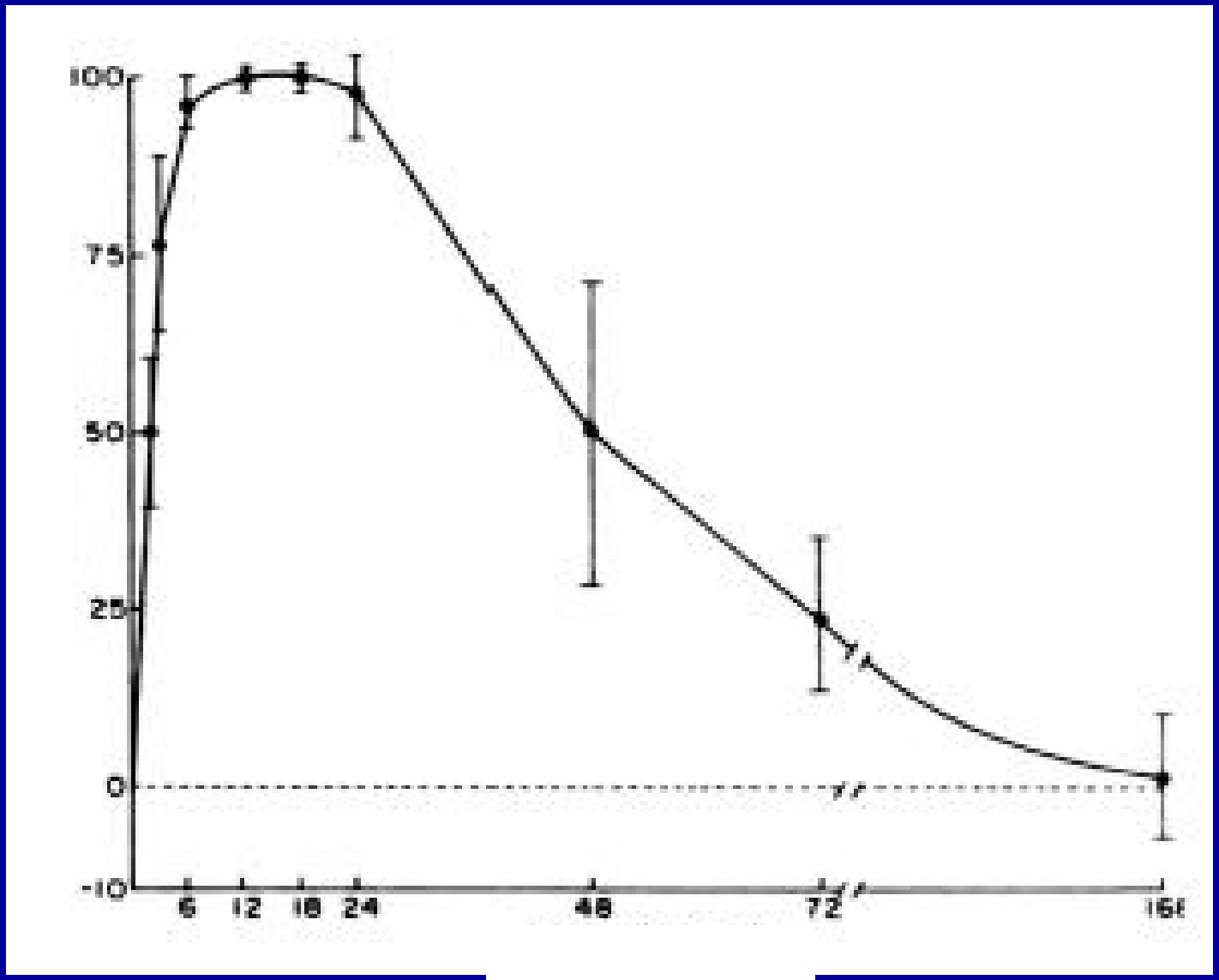
During each visit (every other day)
Received two ½ hour treatments
Diapulse Device

30 matched-pairs based on
Age – sex – degreee of trauma



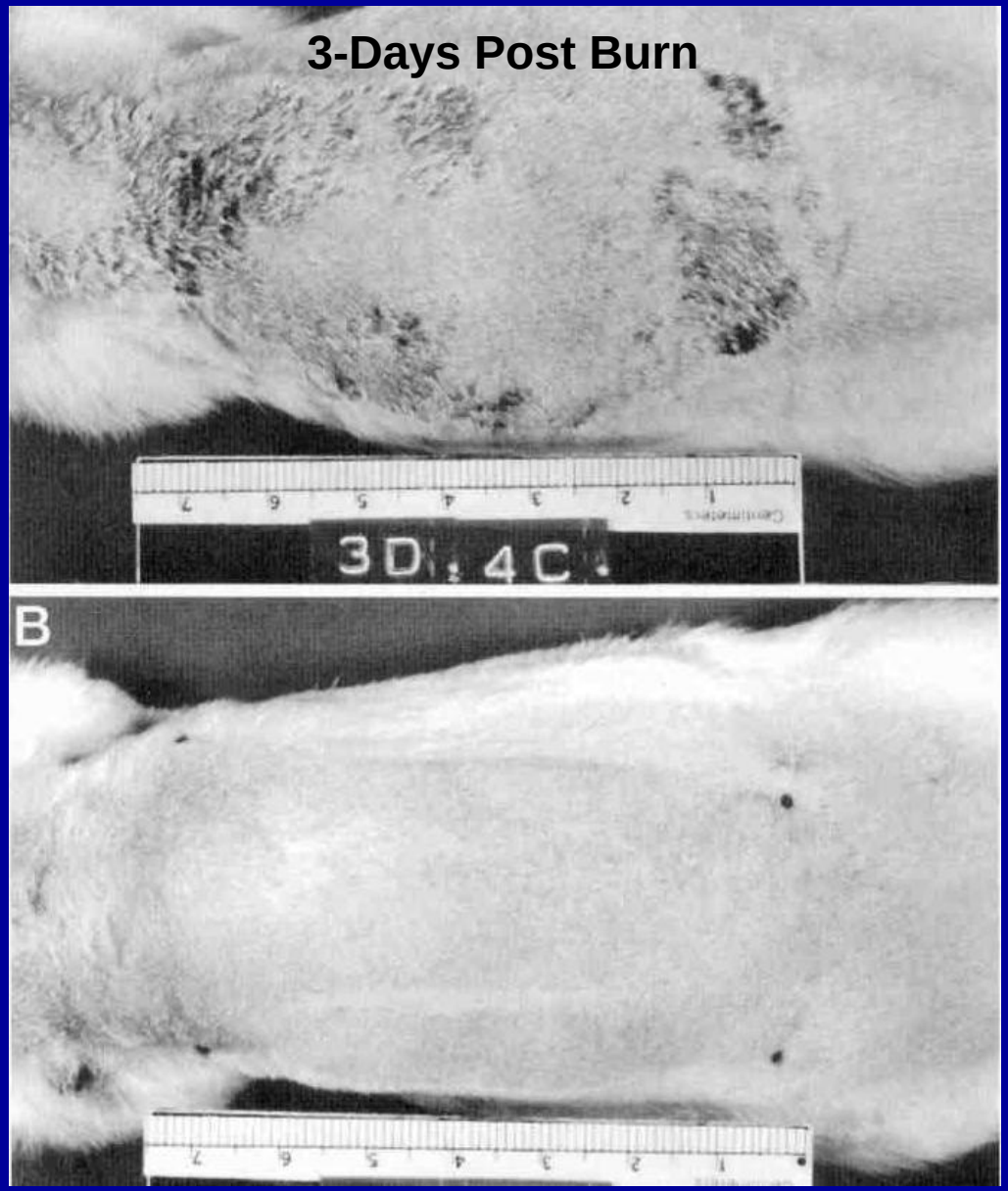
Barclay V et al. Physiotherapy 1983;69:186-188

Experimental Burn Injury



Deming J Burn Care Rehab 2005;26:207-227

Edema Inhibition in Burn Injury



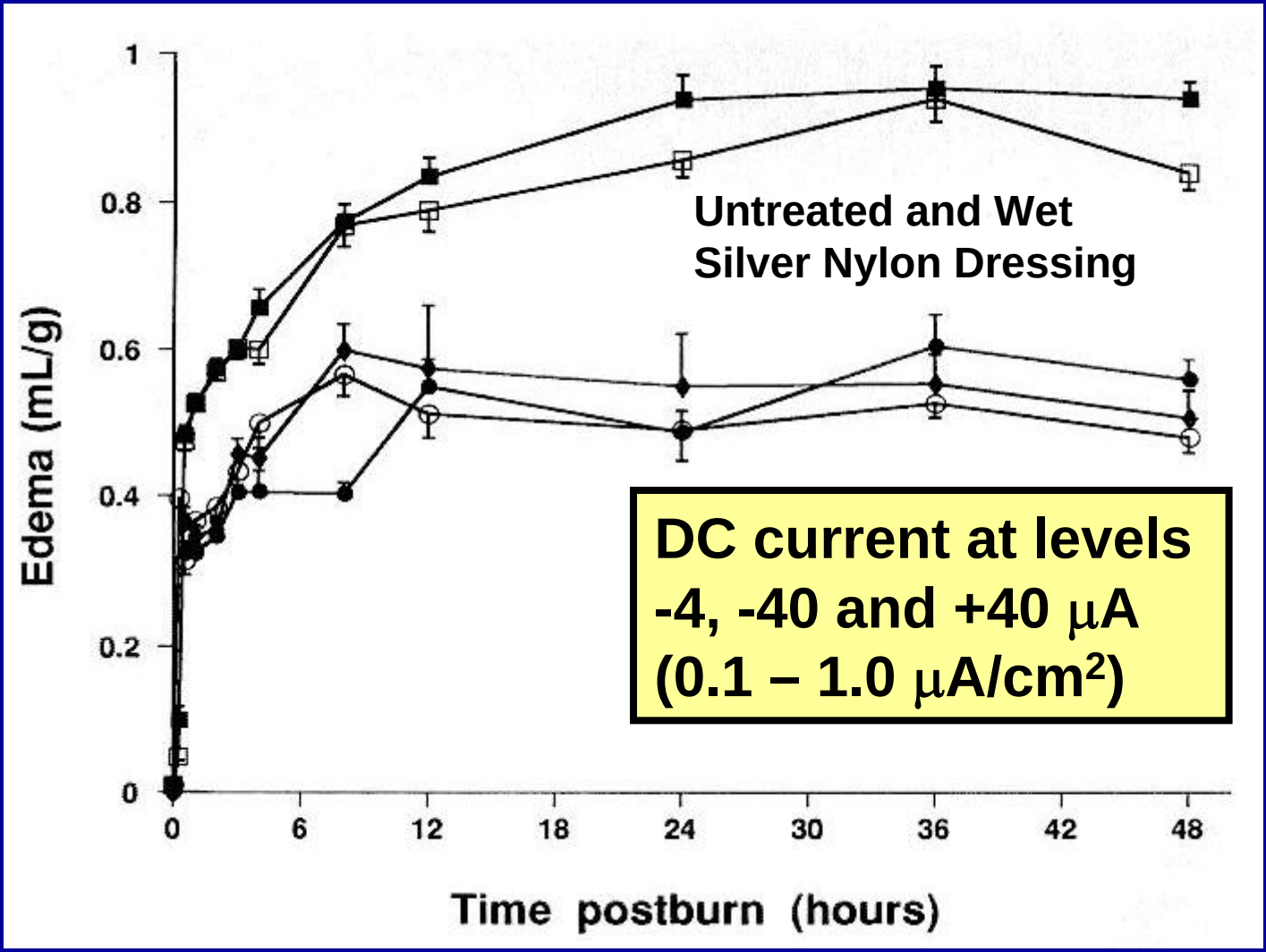
Full Thickness
Scald Wounds
Boiling water for 10s

Untreated

With -40uA

Chu: J Trauma, Volume 40(5). May 1996.738-742

Edema Inhibition in Burn Injury



Chu: J Trauma, 1996;40(5)738-742

Protein Leak Less

SN Dressing Only

Visible Evans Blue
(Bound to albumin)

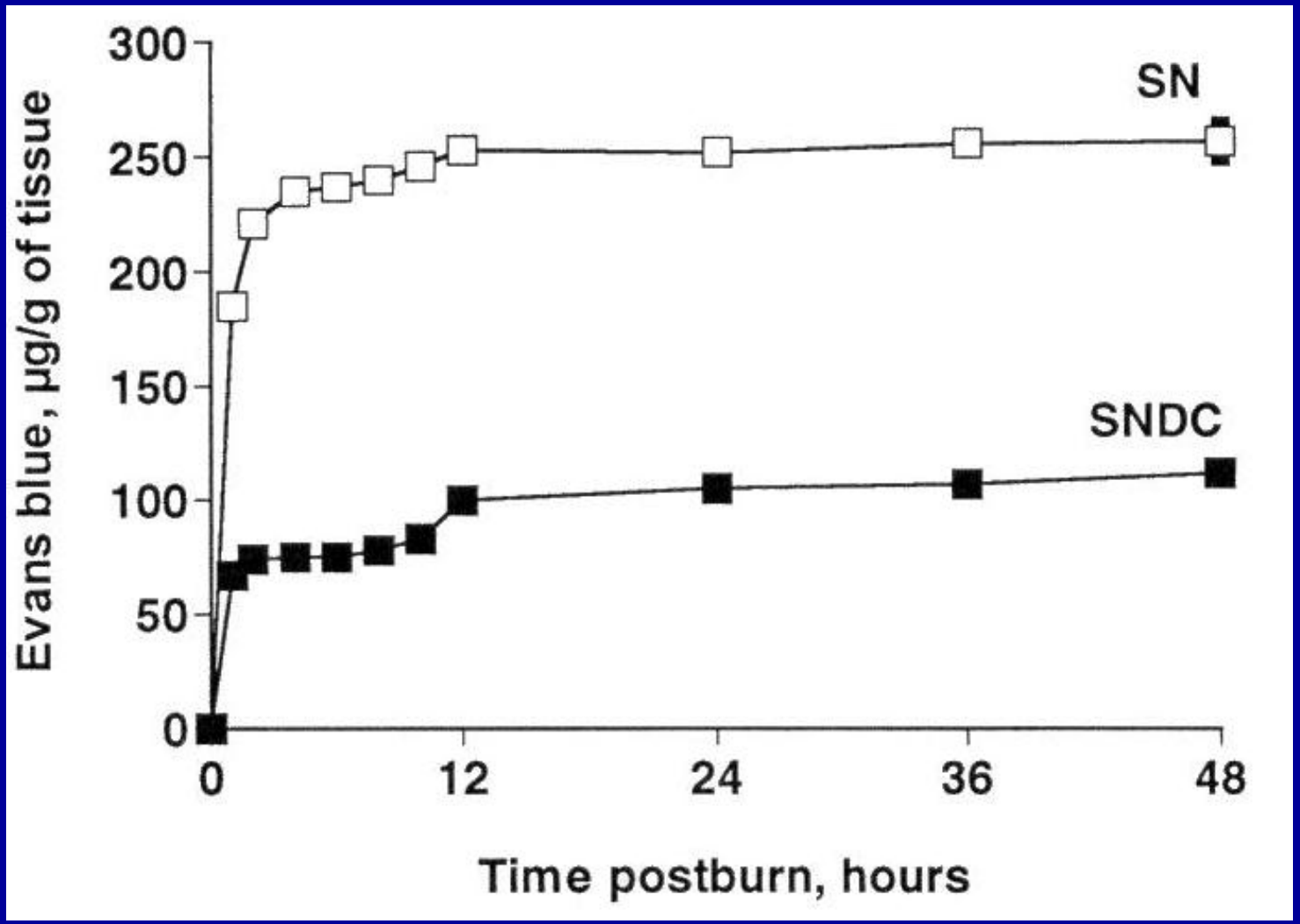
SN Dressing with 40 μA DC

Two Days Post Burn

Cross-Section of Underside of SN

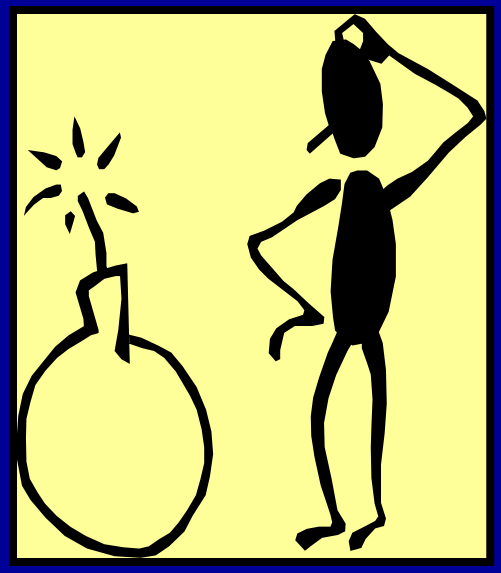
Chu: J Trauma, 1999;47:(2) 294-299

Protein Leak Less



Chu: J Trauma, 1999;47:(2) 294-299

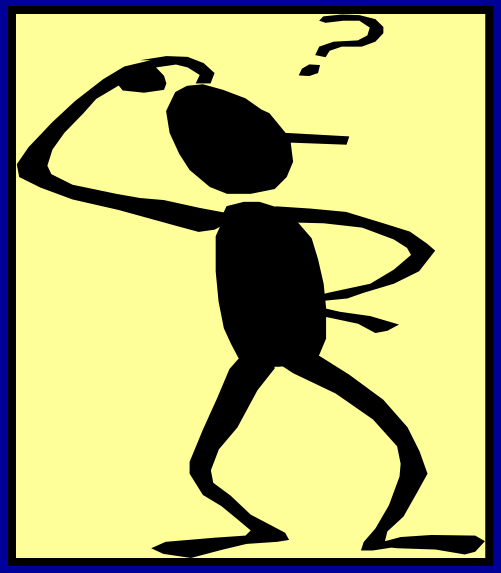
So – What's Going On?



Short Answer – No Real Clue!!

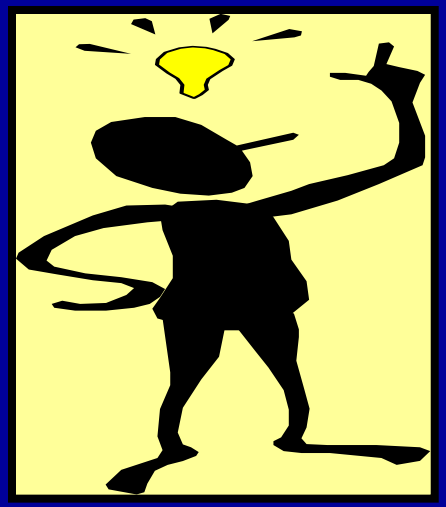
Challenge

As your fertile minds begin processing the vast amount of new information you will get *keep in mind this unsolved problem*



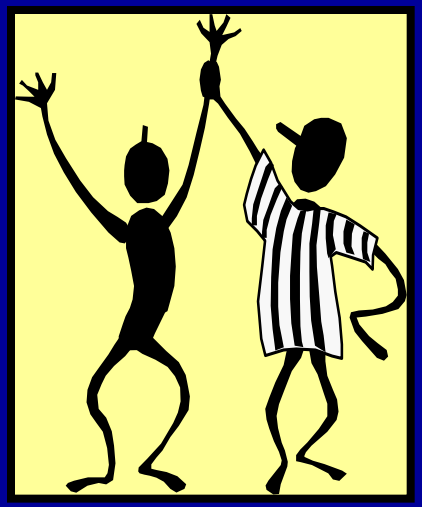
Ponder

Just maybe you will discover the basis for a potential causal – mechanistic link!

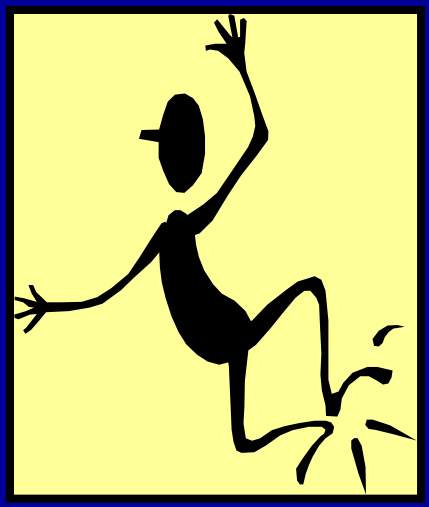


Postulate

Pursue



Pin-it-Down



Party!